Issued January 23, 1909.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 344.

THE BOLL WEEVIL PROBLEM,

WITH SPECIAL REFERENCE TO MEANS OF REDUCING DAMAGE.

BY

W. D. HUNTER,
In Charge of Southern Field Crop Insect and Tick Investigations, Bureau of Entomology.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., November 20, 1908.

SIR: I have the honor to transmit herewith the manuscript of a paper, by Mr. W. D. Hunter, agent in charge of southern field crop insect and tick investigations in this Bureau, dealing with the boll weevil, especially with reference to means of reducing its damage. So many publications upon different phases of the boll-weevil problem have been issued by this Department during the years since the weevil has invaded the United States that it has seemed advisable to present a summary in a single paper of the practical results recorded therein and including the results, as yet unpublished, of the most recent investigations. This purpose has been carried out in the present paper, the publication of which as a Farmers' Bulletin is hereby recommended, superseding No. 216.

Respectfully,

L. O. HOWARD,
Entomologist and Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

ILLUSTRATIONS.

THE BOLL WEEVIL PROBLEM, WITH SPECIAL REFERENCE TO MEANS OF REDUCING DAMAGE.

INTRODUCTORY.

This bulletin, dealing with work done under the direction of Dr. L. O. Howard, Chief of the Bureau of Entomology, is intended to cover in a general way the whole field of the control of the boll weevil. As this control is inseparably connected with the life history and habits of the insect and, in fact, must be based thereon, attention is given to the principal features of the insect's economy. In addition, information is given relating to the amount of damage done, the extent of the infested territory, and such other matters as are of special interest at this time.

Like many of the most important injurious insects in this country, the cotton boll weevil is not a native of the United States. Its original home was undoubtedly in the plateau region of Mexico or Central America, and it may originally have fed upon some plant other than cotton. This is not necessarily the case, however, since there is evidence that the same region is the original home of the cotton plant itself. Previous to 1892 the insect had spread through Mexico, but little is known regarding the extent or rapidity of this dispersion. The records indicate, however, that it had probably caused the abandonment of cotton in certain regions. About 1892 the boll weevil crossed the Rio Grande near Brownsville, Tex. It may have flown across, or it is possible that it was carried over in seed cotton to be ginned at Brownsville. By 1894 it had spread to a half dozen counties in southern Texas and was brought to the attention of the Bureau of Entomology. A preliminary examination, made under the direction of Dr. L. O. Howard by Mr. C. H. T. Townsend, showed the enormous capacity for damage of the pest. Subsequent events have verified in every way the predictions that were made at that time, when the insect had not attracted any considerable amount of attention in the South. Since 1894 the boll weevil has extended its range annually from 40 to 70 miles, although in two instances the winter conditions have been such as to cause a decrease in the infested area. During the first ten years after its advent into this country the annual rate of spread was 5,640 square miles. Since

1901 the annual increase in the infested territory has averaged 26,880 square miles, but in one exceptional season, namely, 1904, 51,500 square miles became infested. Of course, the figures given do not refer to the area in cotton. In many parts of the infested territory the area devoted to cotton is much less than 10 per cent of the total area.

At the present time the weevil is found more or less extensively in five States—Texas, Louisiana, Mississippi, Arkansas, and Oklahoma. In Mississippi 18 counties are infested, in Arkansas 28, and in Oklahoma about one-fifth of the State. The total area infested comprises about 225,000 square miles and this covers about 36 per cent of the cotton acreage of the United States. (See fig. 1.)

DAMAGE.

The damage done by the boll weevil varies greatly from year to year and also in different parts of the infested area. As the rainfall increases the damage becomes greater. In prairie regions, where the insect obtains but little protection through the winter, it never becomes as numerous as in other quarters where favorable conditions for hibernation are found. These facts, together with variations due to winter conditions, make it rather difficult to estimate the exact damage that has been done. Some years ago the writer stated, from the statistics then available, that the weevil caused a reduction of at least 50 per cent of the cotton crop in regions invaded by it, but that after the first few years the farmers generally resorted to proper means to greatly reduce this loss. In many individual cases the means of control perfected by the Bureau of Entomology have been applied so successfully that the crop has been fully as large as before the coming of the weevil. This was not accomplished, however, without somewhat increasing the cost of production. The estimate of an initial falling off in production of 50 per cent was verified by Prof. E. D. Sanderson, formerly State entomologist of Texas, who arrived at his figures in an entirely different way.

The average yield per acre in Texas from 1893 to 1901 (when the weevil had not done damage sufficient to affect the general production) was 0.40 bale. The average since that time, 1902 to 1907, was 0.35 bale. By comparing these periods we have a reasonably accurate basis for estimating the damage the insect has done. The difference is 0.05 bale, or 25 pounds of lint per acre each year. At current prices this means an annual loss of at least $2.25 per acre which has been sustained by the cotton planters of Texas. Assuming that the Texas acreage has averaged 10,000,000, the total loss for the State has annually been $22,500,000.

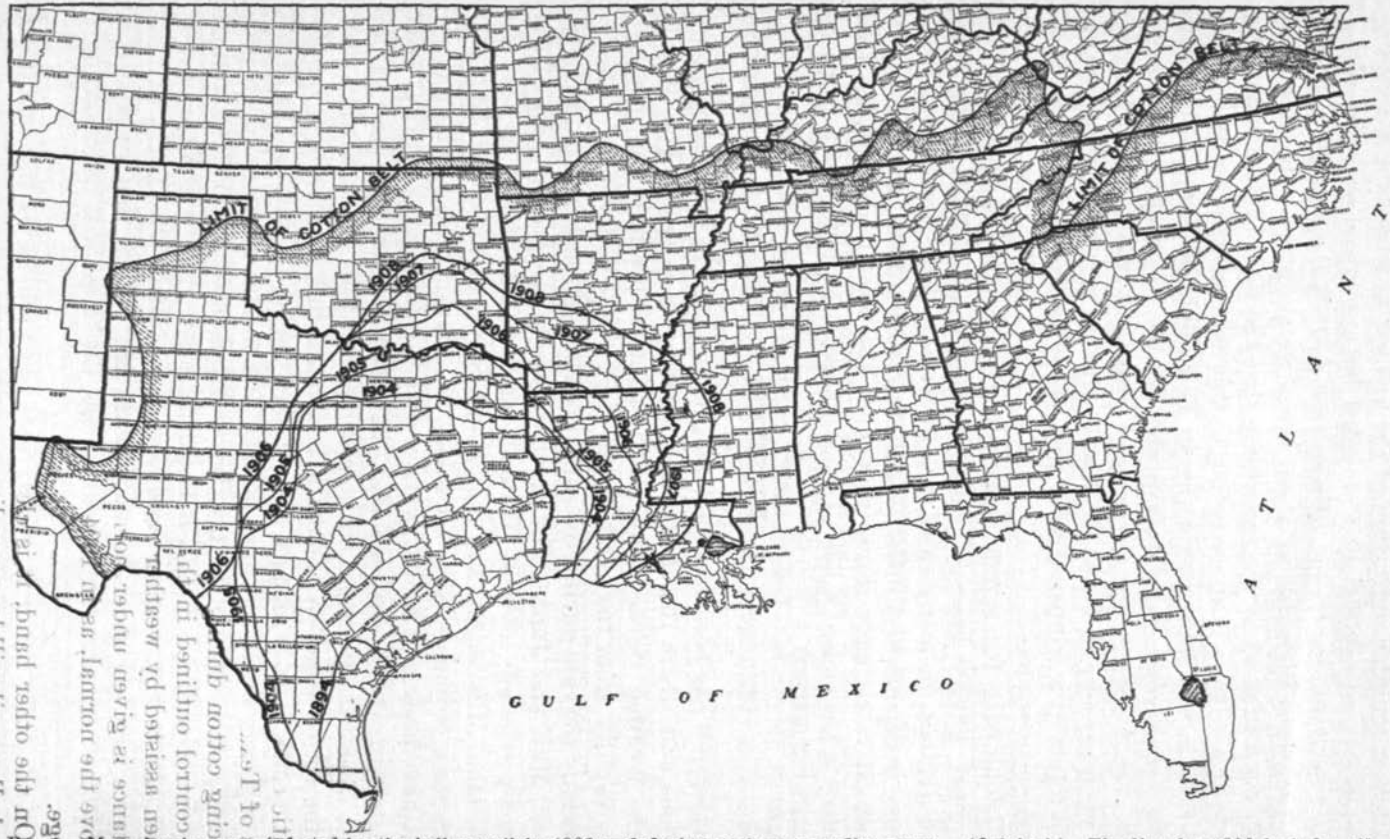

FIG. 4.—Map showing area infested by the boll weevil in 1908 and during various preceding years. (Original.) The line for 1908 includes all territory in which any infestation has been found. Toward the outer part of the infested area very few weevils are to be found. This applies to a belt from 5 to 25 miles wide bordering the line for 1908 on the inside.

Another tangible indication of the manner in which the weevil has affected cotton production is revealed by a comparison of statistics from Louisiana and Texas. From 1899 to 1904 the acreage in Texas and Louisiana increased at about the same proportion, but the crop in Texas decreased at the same time that the crop of Louisiana was increasing. There is an exception to this statement in the years 1900 and 1904, in which the production in Texas did not decrease, but these years were exceptionally unfavorable for the weevil and at the same time very favorable for the general growth of the cotton. In 1907 the yield per acre in Texas (0.24 bale) was the smallest in her history. This followed a winter so mild that more than the usual number of weevils overwintered.

Undoubtedly for several years the boll weevil has caused a loss of about 400,000 bales of cotton annually. Although farmers in older regions, in many cases, are increasing their production, there is loss in the newly infested regions which offsets that gain. A conservative estimate shows that since the weevil has invaded this country it has caused a loss of 2,550,000 bales of cotton, at a value of about $125,000,000.

PROSPECTS.

Reference has been made to the greater damage inflicted in moist regions and where the shelter for hibernation is best. The records of the Weather Bureau show that the annual precipitation increases very rapidly from the West to the East in the cotton belt. This is especially the case during the early growing season of cotton, namely, April, May, and June. The precipitation in the greater part of the cotton-producing area in Texas is normally about 40 inches. In Louisiana, Mississippi, and the eastern States of the cotton belt it is more than 50 inches, and sometimes exceeds 60 inches. The records that have been kept in Texas show that the damage has always been greatest in wet seasons and that the insect has affected land values most where the general conditions approach those of the eastern part of the cotton belt. Without the assistance that is furnished by climatic conditions, especially dry weather during the spring, the farmers of Texas would not have been by any means as successful in producing cotton during the last few years as they have. The system of control outlined in this bulletin increases greatly in effectiveness when assisted by weather conditions. Fortunately in Texas this assistance is given under normal conditions. When this assistance is above the normal, as in 1904 and 1906, the crops will be exceedingly large.

On the other hand, it is clear that the problem of the control of the boll weevil will be more difficult as the pest continues its invasion

of the cotton belt. It can not be considered, therefore, that the problem is as yet completely solved. Better means of control must be devised for the region that is becoming invaded, and, if possible, means must be devised that will reduce the enormous loss that is suffered, especially during unfavorable seasons, in Texas. The principal work of the Bureau of Entomology at this time is in attempting to devise means for this requisite additional control.

For the present there is no occasion to lose hope. Though the eastern planter must expect a more serious problem than that which confronted the farmers of Texas, the means of control outlined in this bulletin, especially the destruction of the hordes of weevils about to enter winter quarters, will enable him to continue production, though probably at a reduced profit. The sooner he adapts his plantation management to the necessary changes the less the loss will be.

WORK UPON WHICH THIS BULLETIN IS BASED.

As has been stated, the danger from the boll weevil was appreciated from the beginning by Dr. L. O. Howard, Chief of the Bureau of Entomology. For about ten years, more or less continuous work on the vulnerable points in its life history and the possibility of control in various ways has been done. At first this was not extensive, although it showed the essential steps necessary in the control of the pest. Later Congress made available large appropriations for the exhaustive investigation of the insect and of means of reducing its damage. Work was begun under the first large appropriation by the establishment of a laboratory at Victoria, Tex., and the beginning of extensive field experiments. It has been the practice from the beginning to carry on field experimental work in direct connection with the laboratory investigations. All means of control suggested by the laboratory work have immediately been tested on large field areas. Later the headquarters of the investigation were moved from Victoria, Tex., to Dallas, Tex., on account of the continued spread of the insect and the necessity for a central location. The Bureau of Entomology has conducted experiments during several seasons on a total of more than 10,000 acres of cotton. This experimental work has been located on well-known plantations throughout the infested territory. The special requirements in different regions have been given particular attention. Almost invariably successful crops have been produced, although special damage, due to local conditions in different regions, has sometimes interfered with the success of the experiments. The present bulletin contains a very condensed report of the results of all this work. The recommendations have all been placed in practical operation under the actual conditions prevailing on different cotton plantations.

Aside from the work directly relating to the boll weevil, which has been conducted by the Bureau of Entomology, the Bureau of Plant Industry of this Department has carried on investigations in its province. These have dealt with the breeding of cottons to obtain earliness and productiveness and with the extensive demonstration of the efficiency of the system of control devised by the Bureau of Entomology as the result of careful studies in the field and laboratory.

In addition to the work done by the Department of Agriculture the States concerned have done their part. Several entomologists have been employed by the State of Texas, namely, F. W. Mally, E. D. Sanderson, A. F. Conradi, and C. E. Sanborn. They have dealt with the boll weevil in connection with the numerous other entomological problems of the State and have contributed valuable results that have been made use of in this bulletin. The State of Louisiana has also done very notable work. Prof. H. A. Morgan and, later, Mr. Wilmon Newell, have added considerably to our knowledge of the weevil and the means of controlling it. In many ways their results are incorporated in this bulletin.

DESCRIPTION AND LIFE HISTORY.

The adult boll weevil is about one-fourth of an inch in length, varying from one-eighth to one-third of an inch, with a breadth about one-third of the length. This measurement includes the snout, which is about one-half the length of the body. Variation in size is due to the amount of food the insect has obtained in the larval stage. Individuals from bolls are therefore nearly always larger than those from squares. The color (grayish or brownish) depends upon the time that may have elapsed after transformation into the adult stage. The recently emerged individuals are light yellowish in color, but this passes to a gray or nearly black shade in a few weeks' time. The general appearance of the insect will be evident from the accompanying illustrations (fig. 2).

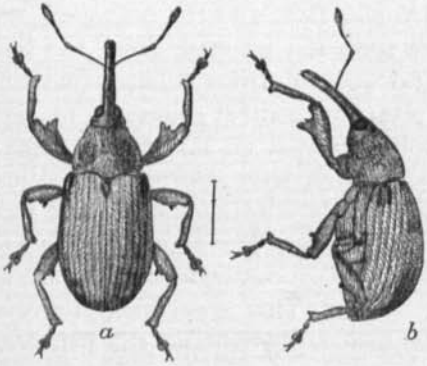

FIG. 2.—Cotton boll weevil: *a*, Beetle, from above; *b*, same, from side. About five times natural size. (Author's illustration.)

Many insects resemble the boll weevil more or less closely. In fact, there are hundreds of species of weevils in this country that may easily be mistaken for the enemy of cotton. Many mistaken reports about the occurrence of weevils far outside of the infested area have been due to mistakes that have arisen on account of this similarity. The only safe way to determine

whether any insect is the boll weevil is to send it to an entomologist for examination. In the field the most conspicuous indication of the presence of the boll weevil is the flaring (fig. 4) and falling of great numbers of squares. However, unfavorable climatic conditions and careless cultivation frequently cause great shedding. If excessive shedding be noticed and the squares upon being cut open show a white, curved grub (fig. 5) that has fed upon the contents, there is little doubt that the boll weevil is the insect causing the damage.

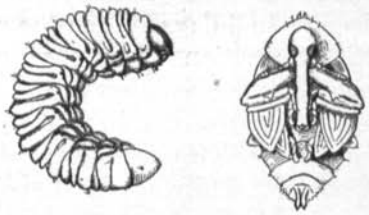

FIG. 3.—Cotton boll weevil: Larva at left, pupa at right. About five times natural size. (Author's illustration.)

The boll weevil passes the winter in the adult stage. In the spring and throughout the fruiting season

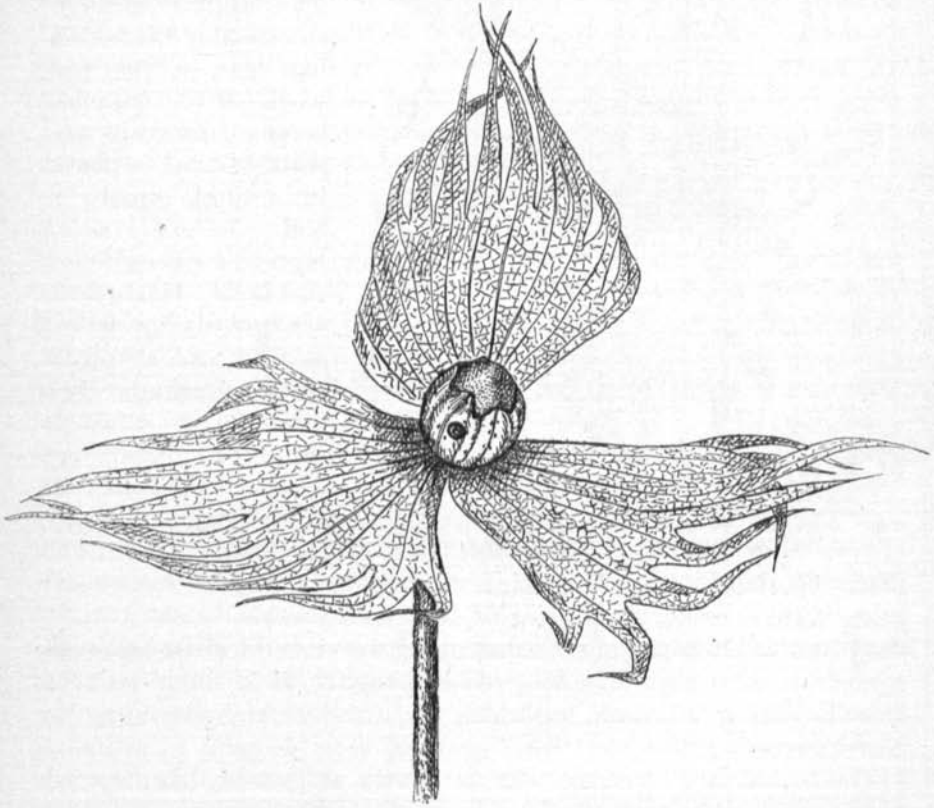

FIG. 4.—Cotton square showing egg puncture of boll weevil and "flaring" of bracts. Natural size. (Author's illustration.)

of cotton the eggs are deposited by the female weevils in cavities formed by eating into the fruit of the plant (see fig. 4). An egg

hatches under normal conditions in about 3 days and the grub immediately begins to feed. In from 7 to 12 days the larva or grub (fig. 3, at left) passes into its pupal stage (fig. 3, at right), corresponding to the cocoon of butterflies and moths. This stage lasts from 3 to 5 days. Then the adult issues and in about 5 days begins the production of another generation. Climatic conditions cause considerable variation in the duration of the stages, but on an average it requires from 2 to 3 weeks for the weevil to develop from the egg to the adult. Males and females are produced in about equal numbers. The males feed upon the squares and bolls without moving until the food begins to deteriorate. The females refrain from depositing in squares visited by other females. This applies throughout most of the season, but late in the fall, when all the fruit has become infested, several eggs may be placed in a single square or boll. As many as 15 larvæ have been found in a boll. The squares are greatly preferred as food and as places for depositing eggs. As long as a large supply of squares is present the bolls are not damaged to any serious extent. The bolls, therefore, have a fair chance to develop as long as squares are being formed. Whenever frost or other unfavorable weather causes the plants to cease putting on squares the weevils attack the bolls. A conservative estimate of the possible progeny of a single pair of weevils during a season beginning on June 20 and extending to November 4 is 12,755,100.

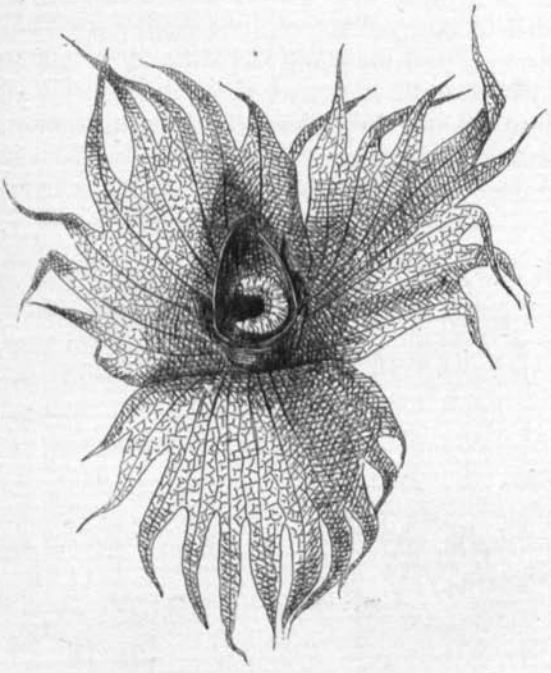

FIG. 5.—Cotton square showing boll weevil in position. Natural size. (Author's illustration.)

The cotton boll weevil, as far as known at present, has no food plant other than cotton. This has been determined by planting various plants related to cotton in the vicinity of infested cotton and in cages in which weevils were placed. It has therefore been demonstrated beyond any doubt whatever that the insect is restricted to the

cotton plant for food. When confined in bottles, the weevil will partake of various substances, such as apples or bananas; but this is only under the stress of starvation. Under natural conditions they would pay no attention to these substances.

The boll weevil is strictly diurnal in its habits. Repeated observations made in the field at night have shown that it is not active after sundown. Unlike some related insects, it is not attracted to lights. The fact that somewhat similar species do come to lights in great numbers at times has frequently caused unfortunate confusion.

An interesting habit of the boll weevil is to feign death; that is, to "play possum" or "sull," as it is popularly called. When disturbed, the insects generally contract their limbs and drop to the ground. This habit is not equally strong in all individuals. It has been taken into consideration in plans of control, as will be described beyond.

The age to which weevils live varies under different conditions. During the winter the longevity is much greater than in the summer. During the summer season the majority of weevils do not live longer than 60 days. During the cooler part of the year many of them live as long as 6 months. The longest-lived weevil on record lived from December 10 to the following October, a period of about eleven months. Undoubtedly such prolonged life is exceptional.

HIBERNATION.

As has been pointed out, the boll weevil passes the winter in the adult stage. In the fall when frosts occur, immature stages may be found in the squares or bolls. Provided the food supply is sufficient, many of these immature stages continue their development at a very slow rate and adults finally emerge. Thus there may be a somewhat continuous production of adults during the winter. Ordinarily, however, this is not conspicuously the case, since the frosts that destroy the cotton generally kill practically all of the immature stages of the weevil.

With the advent of cool weather in the fall the adult boll weevils in cotton fields begin to seek protection against the winter. They fly from the fields in every direction, although their movements are governed partially by the prevailing winds. They may fly into hedges, woods, cornfields, haystacks, farm buildings, or other places. Specimens have been found in such situations, and also in considerable numbers in Spanish moss growing from trees some distance above the ground. A number of weevils also obtain hibernating quarters without leaving the cotton fields. These may crawl into cracks in the ground under grass, weeds, and other trash, and into the burrs from which the cotton has been picked. In some cases several thousand weevils per acre have been found hibernating in such situations. Here, however, the mortality is greater than where the protection is

better. The majority of weevils that hibernate successfully do not pass the winter in the cotton fields. This has been shown by many experimental observations, and is demonstrated every year in the infested territory by the appearance of the first damage in the immediate vicinity of weeds and other places where conditions for protection are favorable.

During the winter the weevils take no food and remain practically dormant. On especially warm days they may move about to a certain extent. During the very mild winter of 1906–7 hibernating weevils were found moving about more or less throughout the period from November to March.

The number of weevils hibernating successfully has been determined very accurately for different conditions. Out of 25,000 weevils 2.82 per cent survived the winter of 1905–6. These weevils were placed in a variety of conditions that must have approached those which weevils must naturally encounter. The winter referred to was practically a normal one as far as temperature and precipitation were concerned. In extensive work during the winter of 1906–7, out of 75,000 weevils 11.5 per cent survived. As in the preceding case, these weevils were placed under diverse conditions in different cages. These conditions ranged from the most favorable to the least favorable, i. e., from an abundance of protection to practically none. The survival obtained is undoubtedly very close to that occurring under diverse natural conditions of that winter. It must be emphasized that the winter of 1906–7 was abnormally warm. It is undoubtedly true that the rate of survival was much higher than usual. It is supposed that the results of the previous year must approach the average. In other words, less than 3 per cent of the weevils entering hibernation can be expected to survive the winter under average conditions. The tremendous importance of still further reducing this percentage must be evident.

Emergence from hibernation depends primarily upon temperatures in the spring, although there are other minor factors concerned. Generally, from the first to the middle of March the temperature has become high enough to cause weevils to begin to emerge. Naturally, the individuals under the heaviest protection are affected latest by the temperature. The consequence is, that emergence from hibernating is a prolonged operation. During one season (1906) it extended from the middle of March to the 28th of June; during another (1907) from the middle of February to about the first of July. During each of these periods there was a comparatively short time—about ten days—of rapid emergence, preceded by an initiatory movement and followed by a period during which the number emerging day by day decreased with rapidity.

HOW NATURE ASSISTS IN DESTROYING THE BOLL WEEVIL.

In the preceding paragraph attention was called to the possible production of 12,755,100 offspring in a single season by one pair of weevils. As a matter of fact, nature has provided a number of agencies that serve to prevent such excessive multiplication. The most conspicuous of these agencies are heat and insects that prey upon the weevil.

Effects of heat.—When infested squares fall to the ground they may become so heated that the larvæ are killed in a very few minutes. The insect in this stage can not leave the square, as it has no means of locomotion whatever. Where the infested squares are subjected to the unobstructed rays of the sun the mortality is very high. This explains the well-known fact that dry seasons are unfavorable to the weevil, and indicates great difficulty in controlling the insects in regions where the precipitation is heavy. The more rankly the plants grow and the more the ground is shaded, the less effect in weevil control can be expected from heat. Nevertheless, in many cases in Texas the enormous total of 40 per cent of all the immature weevils in cotton fields inspected have been found to be destroyed through this agency. It was also found, from examinations in many quarters, that the extent of destruction held a direct relation to the amount of shade. When there was no shade practically all of the larvæ and pupæ were killed outright. Some of the important means of control, to be described later, are based upon this consideration.

Insect parasites.—The second of the important agencies provided by nature for the control of the weevil is a large number of predaceous insect enemies. These consist of a variety of forms which prey upon the boll weevil. Forty-five species of these enemies are known. Of these, 23 are parasites, which by means of their ovipositors place eggs on the immature stages of the weevil within the square or boll. The young of the parasite develops by feeding upon the immature boll weevil, which it ultimately kills. A parasite instead of a boll weevil emerges from the injured fruit. Special studies on these parasites have led to many suggestions for practical control. Moreover, the parasites seem naturally to be increasing in numbers and effectiveness against the boll weevil. In one instance in 1907 the mortality due to parasites in a field near Robson, La., was 77 per cent. About the same time 61 per cent of the weevils in a certain field near Victoria, Tex., were killed by parasites. These enemies of the weevil have existed in the country for an indefinite time. Their natural habit has been to prey upon weevils more or less related to the boll weevil that have occurred in this country for many years. They never feed on vegetation. It is undoubtedly true that they are

now turning their attention from the original hosts, which are generally not very numerous, to the boll weevil, which offers abundant and favorable opportunities for reproduction. They thus ally themselves with the farmer for the protection of the cotton crop. In the following pages numerous suggestions will be made regarding the means that the farmers may take to increase the effectiveness of the work of these parasites in reducing the numbers of the boll weevil.

Other insect enemies.—In addition to the true parasites described above, the boll weevil suffers from a number of insects which are not parasites in a strict sense but prey upon it as food. The principal ones of these predatory enemies are ants. Of these, 12 species are known to attack the weevil. They are the minute brown ants and yellowish ants that occur frequently in cotton fields and are observed running over the plants or on the ground. Their work is not against the adult weevils, but against the immature stages in the squares. Some species devote their attention principally to the squares that have fallen to the ground, while others habitually seek the insects within the squares that remain hanging on the plants. The larva of the weevil, incased in a thin covering, offers a source of food that the ants are not inclined to overlook. They gnaw through the thin shell inclosing the weevil larva and the latter is soon destroyed. In some cases more than half of the immature stages in fields have been found to be destroyed by ants alone. To find 25 per cent so destroyed is not a rare occurrence. In this bulletin methods will be pointed out for making use of these friends of the farmer and increasing the important effect they naturally have in reducing the numbers of weevils.

Other factors in natural control.—In addition to the principal factors in natural control which have been mentioned there are several of minor importance. Among these may be mentioned proliferation, which sometimes crushes the immature weevils, and determinate growth, which may prevent the development of the fall broods of the weevil. Attention is also called to the agency of birds in the destruction of the boll weevil, which has been given full attention in the publications of the Biological Survey of this Department.

DISSEMINATION.

The boll weevil moves from place to place by flight. Although it is a weak flyer compared with many insects, it has been known to cover a distance of more than 40 miles in a very short time. Its flight can not be prolonged, but successive short flights, especially in connection with favorable winds, often carry the insect to considerable distances. This is the case, however, only during the so-called dispersion period, which extends from about the middle of August to the end of the season. During the rest of the year the weevil is

little inclined to fly. There is always a movement from fields in all directions in search of hibernating quarters in the fall and a corresponding movement from such quarters to the cotton fields in the spring. Nevertheless, when the insects reach cotton fields in the spring there is little further movement until the general dispersion begins. Ordinarily between the middle of August and the first of September the weevil seems to be seized with an instinct to migrate. It was thought at one time that this movement was forced by excessive reproduction and took place only when all squares and bolls, or the majority of them, became infested. Investigations have shown, however, that the dispersion takes place frequently when the fields are only slightly infested. In other words, the insect has a well-developed instinct for extending its range into new territory. It is this instinct that has caused the extension of the infested area in the United States year by year. The weevil does not fly in any particular direction except as governed by the wind. If there is no wind or only a light one, a weevil is as likely to fly in one direction as in another. The individuals carrying the infestation into new regions have been those that happen to radiate in the direction of previously uninfested territory.

The fact that the weevil moves about but little except at one season is of great benefit to the farmer. As the movement referred to does not begin until after the time when a crop is normally made, it amounts to but little after a region has become infested. On the other hand, the limited movement at other times of the year makes it possible for any individual farmer to obtain the best results from his own efforts in fighting the pest. The danger of his efforts being thwarted by the arrival of weevils from fields where no precautions have been taken is not as important as is sometimes considered. In fact, it is not important enough to warrant any farmer in deferring action on account of the indifference of his neighbors.

The above statements give only an outline of the life history and habits of the boll weevil. More complete information can be obtained from Bulletin 51 of the Bureau of Entomology, which may be obtained for 15 cents upon application to the Superintendent of Documents, Government Printing Office, Washington, D. C. In this connection the writer wishes to emphasize the following four important points that have a direct bearing upon control:

(1) It has been demonstrated that the boll weevil subsists on no other food than cotton.

(2) The weevil moves about but little until late in the cotton-growing season; in fact, not until the time when the crop is normally set.

(3) Winter conditions naturally reduce the number of weevils enormously; indeed, the winter is the critical period in the life history of the pest.

(4) Natural agencies operate to destroy a very large percentage of weevils. These agencies are increasing in effectiveness and already are of very great importance to the farmer in reducing his loss. Otherwise it would often be practically complete.

MEANS OF CONTROL.

It will be evident from the preceding statements regarding the life history and habits of the weevil that its control is beset with many difficulties. In fact, it is probably the most serious insect pest that is now known. Its insidious methods of work in the immature stages within the fruit of the cotton plant, the habit of the adult in seeking protection for the greater part of the time under the bracts of the squares, and its enormous power of reproduction and adaptability to new conditions, all tend to place the boll weevil in a class by itself. The difficulties are increased by the necessary procedures in raising cotton. In spite of these difficulties fairly satisfactory means of control are known. A large share of the reasonable success of the warfare against the pest is due to the assistance furnished by natural agencies, which commonly destroy many more weevils in a cotton field than the farmer could by any known method or methods.

Burning infested plants in the fall.—Foremost among the methods of control is the killing of the hordes of adult weevils that are ready to enter hibernation in the fall and the prevention of the development of millions more that would later emerge to pass through the winter. This is accomplished by burning the infested plants in the fall after the weevils have become so numerous that there is no prospect of the maturity of any additional crop. There are many vital reasons why the wholesale destruction of the weevils in the fall should be practiced by every cotton planter in the infested region. Some of these are stated below:

First. Hordes of adult weevils, many for each plant in the field, are killed outright.

Second. Many more weevils that are in the immature stages, possibly as many as a hundred for each plant in the field. are also killed.

Third. The few adult weevils escaping will be weakened by starvation and the great majority will not have sufficient strength to pass through the winter.

Fourth. The development of the late broods, which experiments have shown furnish the vast majority of weevils that pass through the winter, is cut off immediately. In this way hundreds of weevils

that would develop from each plant are absolutely prevented from so doing.

Fifth. The removal of the infested plants with the weevils facilitates fall or early winter plowing, which is the best possible procedure in cotton raising. Moreover, this plowing assists greatly in the production of an early crop the following season.

In short, in the fall the weevil is at the mercy of the planter as it is at no other time. If the planter desires to kill the insect he can do so. Work in weevil destruction at that time far outbalances all remedial measures that may be applied at all other times of the year.

Many hundreds of cases are on record showing the benefit from the fall destruction of plants in the control of the boll weevil. The process has not been taken up as generally as it should, but individual instances everywhere show its value. A large amount of experimental work done by the Bureau of Entomology has all pointed clearly toward the supreme importance of this essential method in control. In an experiment performed by the Bureau of Entomology in Calhoun County, Tex., the stalks growing on 410 acres of land were destroyed early in October. Careful records kept during the following season showed that this work had increased the production more than a quarter of a bale per acre over the crop on the check area where such work was not done. Computing the increase in the crop at the current prices, the advantage from the work in the experiment amounted to $14.56 per acre. This was about 29 times the cost of uprooting and burning the plants, as shown by the amount actually paid by the Department for the work. Circumstances surrounding the experiment, referred to in Circular 95 of the Bureau of Entomology, show that the advantage was probably considerably greater than has been indicated here. At any rate, the estimate given is most conservative. In this instance the cotton destroyed was isolated and the results are perhaps somewhat more conspicuous than would have been the case where there were hundreds of cotton fields in the neighborhood. Nevertheless, experience with fields surrounded by others that have been given no attention has shown a great advantage from taking the proper step in the fall. Of course, concerted action will add to the effectiveness of the work and should be followed in every community.

In addition to the field work by the Bureau of Entomology and by many practical planters, a great deal of work has been done in large cages, where the conditions could be studied most carefully. In this way the exact relative advantage of fall destruction at different dates has been determined. It has been shown in this connection that the earlier the work can be done the better the results will be. For instance, seven times as many weevils survived the removal of the in-

fested plants on November 12 as survived after similar work on October 13.

Mr. J. D. Mitchell, of the Bureau of Entomology, calls attention to a striking example of the value of the fall destruction of the weevils that came to his attention in 1908. On opposite sides of the Guadaloupe River near Victoria, Tex., were two farmers, each having about 40 acres in cotton. In one case the stalks were uprooted and burned in September, 1907, and in the other they were allowed to stand until shortly before planting time in the spring of 1908. They were equally good farmers, and the soil was the same on the two places. In the first case the crop of 1908 was 15 bales and in the other 3½ bales. The work done during the preceding fall plainly increased the crop about fivefold.

No definite rule can be laid down as to the proper time for destroying the weevils upon and in the fruit of the plants in the fall. In general, the proper time is whenever the weevils have reached such numbers as to infest practically all of the squares that are being set. This may occur a month or more earlier in some seasons than in others. Fall destruction as late as November will accomplish much, but several times the number of weevils can be destroyed if the work be done in October. Therefore the rule should be to destroy the infested plants at the earliest possible date in the fall. It is much better to sacrifice a small amount of cotton than to defer the operation. The loss will more than be made good by an increase in the next crop.

Some objections to the work of destroying the weevils in the fall are frequently raised. The principal one is that the labor supply is insufficient to enable planters to have the crop picked out in time for such fall destruction as is recommended.[a] One of the respects in which the boll weevil will make revolutionary changes in the system of producing cotton is that smaller areas than formerly must be cultivated by each hand. The production can best be kept up or increased by more intensive methods on smaller areas. If this principle be put in operation on plantations in so far as it is practicable, the objection to fall destruction on account of the scarcity of labor will tend to disappear. A minor objection raised is that the process tends to impoverish the soil. As a matter of fact, the burning of the stalks removes only a small amount of the fertilizing elements, and, moreover, the practice now is to burn the plants a few months later. In

[a] In this connection attention is directed to one of the many advantages of having the crop picked out early. The earlier this is done the cleaner the lint will be, and the better the price. Moreover, the longer the unpicked cotton remains in the fields the greater will be the amount that falls to the ground and soon passes beyond recovery. From every standpoint the cotton should be picked as rapidly as possible.

most cases the humus is more important than the fertilizing elements themselves. The use of commercial fertilizers in one case and the practice of green manuring in the other will solve both of these difficulties.

METHODS OF DESTROYING WEEVILS IN THE FALL.

The reader is referred to Circular 95 of the Bureau of Entomology for particulars regarding methods of destroying the weevils in the fall. In this connection it will be stated that the proper method, in general, is to uproot the plants by means of plows, and to burn them as soon as possible. Other methods are applicable to different conditions. As soon as the plants are uprooted they should be placed in piles or windrows, which will utilize the leaves in the burning. The difficulty in one method of removing the plants—that of cutting them off near the surface of the ground with a stalk cutter or ax—is that during mild seasons many sprouts soon make their appearance to furnish food for weevils that would otherwise starve during the fall or winter. If the ordinary stalk cutter be followed immediately by plows, some of the desired results will be obtained. The great objection is that the innumerable weevils in the bolls and squares will be allowed to develop. Nothing but uprooting and burning will come near meeting the exigencies caused by the weevil.

Grazing.—In some cases the grazing of the fields with cattle, sheep, or goats can be practiced. This is only a local measure, however, since the supply of live stock in regions where the bulk of the cotton crop is produced is insufficient for the purpose.

Sprout cotton.—A most important result of the proper manipulation of the plants in the fall is that no stumpage or sprout cotton is allowed to grow. The occurrence of such cotton in southern Texas and occasionally in southern Louisiana is there the most important local difficulty in the control of the boll weevil. Sprout plants are sometimes encouraged on account of the production of a small but very early crop. This may have been defensible before the advent of the boll weevil, but at the present time the practice is undoubtedly the worst that could possibly be followed. The sprout plants serve only to keep alive myriads of weevils that could easily be put out of existence by the farmer.

Volunteer cotton.—In addition to stumpage cotton, volunteer cotton, in the strict sense, is of considerable importance in weevil-infested areas. The seed scattered about seed houses and gins frequently give rise to plants, both in the fall and in the spring, that furnish food and breeding places for weevils. It is needless to call attention to the fact that all such plants should be destroyed. They are merely aids to the enemy.

DESTRUCTION OF WEEVILS IN HIBERNATING PLACES.

After the weevil-infested plants have been removed from the field in the fall the farmer can add strength to the blow he has given the insect. As has been stated previously, many of the hibernating weevils are not to be found within the cotton fields nor in their immediate vicinity. Nevertheless, most of those remaining in the field can be destroyed, and this is undoubtedly well worth the effort that it will cost. In many cases surprising numbers of weevils have been found hibernating in the trash and rubbish on the ground in cotton fields. In January, 1907, in one instance, 5,870 weevils per acre were found, of which 70 per cent were alive. This was undoubtedly exceptional, but most of the many examinations made showed more than 1,000 live weevils per acre in old cotton fields. The insects so found are largely at the mercy of the farmer. He can destroy many by carefully raking up the trash and burning it. Plowing and subsequent harrowing of the land will add to the destruction. This work would well be worth while on general agricultural principles if no weevils whatever were destroyed. With the weevil present, that farmer invites loss who does not clean the fields to the best of his ability.

Of the multitudes of weevils that fly out of the cotton fields for hibernation not all are beyond the reach of the farmer. Many are to be found along turn-rows, fences, hedges, and old buildings. The cleaning and burning of hedges, fence corners, and in general the removal of trash from the vicinity of fields will destroy many weevils that would live to assist in the destruction of the crop.

Old sorghum fields, on account of their roughness and the fact that the heavy stubble catches trash moved about by the wind, have been found to furnish very favorable winter quarters for the weevil. The farmer should pay special attention to such fields. They have frequently been found to be the source of the first weevils to damage the cotton in the spring. A little work in the fall or winter will result in the destruction of practically all of the weevils found there. Old cornfields, while not as important as sorghum fields, also furnish favorable hibernating quarters and should be carefully cleared by the farmer who desires to minimize the weevil damage on his place.

A very practical illustration of the danger of trash in aiding in the hibernation of the weevil has occurred repeatedly on the experimental farm of the Bureau of Entomology near Dallas, Tex. Across a narrow lane on one side of the experimental cotton field of 40 acres is a small peach orchard in which the weeds have been allowed to grow unchecked from year to year. Every season the first weevil infestation in the cotton is found in the immediate vicinity of the orchard. In fact, the infestation always starts at that point and

radiates into the field. If it were possible to eliminate the hibernating quarters across the lane—and this means only the prevention of the growth of weeds—there would evidently be a considerable reduction in weevil damage, especially early in the season when it is most critical.

LOCATING FIELDS TO AVOID WEEVIL DAMAGE.

The illustration just given emphasizes a method of averting damage by the weevil that can be followed in many individual cases. All planters that have had experience with the weevil know that the portions of their properties near the timber or other hibernating quarters show the first damage by the weevil and consequently the least production. Of course, it is not always possible to plant other crops in such situations. Nevertheless, very frequently farmers can avoid damage by devoting the particular fields known to be most susceptible to weevil injury to other crops. This is not pointed out as a general recommendation. In many cases it would be entirely impracticable, but its importance should be realized by planters in regions where every possible precaution must be taken.

CROP ROTATION.

Save in very exceptional cases the boll weevil never does as much damage on land where cotton follows some other crop as on land where cotton follows cotton. This is due to the fact, as has been pointed out, that the weevils do not fly very far from their hibernating quarters in the spring. Therefore it is evident that a proper rotation of crops may be followed to assist in the fight against the boll weevil. As in the case of the location of the fields referred to above, the recommendation here made is no panacea. Nevertheless, rotation can be made to assist in fighting the weevil, aside from the many other advantages that are known to come from it.

PROCURING AN EARLY CROP.

Although the destruction of the weevils in the fall is the great essential step in controlling the insect, it can not be depended on exclusively. The full benefits of the fall work and the maximum crop can not be obtained unless the next great step, procuring an early crop, is also taken. In fact, the success of the farmer in producing cotton in regions infested by the boll weevil will depend directly upon the extent to which he combines the various methods described in this bulletin.

There are certain localities where the conditions cause the soil to be "late" or "slow." For instance, the planters on the Red River in

Louisiana state that they can procure early crops on their "front" land, but that such is difficult or impossible on the fields back from the river. This is largely a matter of drainage. In some sections in Louisiana and Mississippi the essential step in obtaining an early crop will be largely a question of drainage. Lands so situated that they can not be drained economically to the extent that allows an early crop must be devoted to crops other than cotton.

The advantage of early planting has been demonstrated in every one of the numerous experiments made by the Bureau of Entomology and has now become the general practice among farmers. The reasons for the efficiency of early planting are not far to seek. The small numbers of weevils passing through the winter must have considerable time to multiply. They are unable to breed until squares are put on by the plants, since the food obtained from the fruit is required before reproduction can begin. Moreover, at the time the first squares are put on, the development of the immature stages is comparatively slow, not reaching the very rapid rate that obtains during the warm days and nights of the summer. For these reasons it is possible for the farmer to rush his crop in such a way that a large number of squares and bolls will be formed before the weevils have multiplied to a serious extent. Of course, under usual conditions the weevils will ultimately multiply so that the crop put on after a certain date will all be destroyed. This, however, is of no importance, since a top crop in weevil regions is entirely out of the question. The time it takes the weevils to recuperate after the vicissitudes of winter, especially after the entirely feasible destruction of multitudes in the fall, can thus be taken advantage of in the production of a crop.

Removal of plants.—The first step in the procuring of an early crop is the early removal of the plants, so that the land may be plowed during the fall or winter and the seed bed given thorough and early preparation. In fact, such preliminary preparation should be followed for the production of the best cotton crop under any conditions. The recommendation made is therefore neither onerous nor revolutionary. The tendency has often been to neglect the cotton fields until spring or at least until "after Christmas." It would repay the farmer many times if he would take the slight additional trouble of plowing the fields before that time. Not only a plowing, but one or more harrowings should be given the land during the winter.

Use of commercial fertilizers.—An important step in procuring an early crop under many conditions is the use of commercial fertilizers.

In many large areas in the cotton belt the land is not impoverished to the extent that it actually needs fertilizers under normal conditions. It has been demonstrated many times by the different experiment stations in the South that the maturity of cotton can frequently be hastened materially by the use of fertilizers, especially those containing a high percentage of phosphoric acid. The recommendation for the use of fertilizers in weevil regions, therefore, does not imply the exhaustion of the soil. It merely means that fertilizers place in the hands of the farmers an important means of averting damage by the boll weevil. The proper use of fertilizers is a very complicated matter. In fact, in the light of all present knowledge only the most general rules can be laid down. Each farmer must experiment with the soil or different soils upon his own place and study the results to obtain the greatest benefit from fertilizers at the smallest cost. In the eastern portion of the cotton belt most of the farmers have acquired this experience. In the West, however, this training is lacking. Farmers interested should communicate with the State experiment stations and obtain the latest bulletins regarding experiments with fertilizers in their own regions.

Use of early varieties of cotton.—Next in importance to early preparation, and fertilization (where necessary), in obtaining an early crop of cotton comes the use of early varieties. In all experiments that have been undertaken the advantage in the use of early varieties has been conspicuous. As in other cases, the greatest advantage in this instance comes with the joint use of the other expedients recommended for weevil control. By far the best method for obtaining seed of early maturing cotton is for the farmer to carry on the selection himself. In many cases, however, this is impracticable. Under such circumstances the farmer should obtain seed of improved varieties from dealers or such individual farmers in the locality as have been able to carry on careful seed selection. A valuable publication on the selection of cotton varieties has been published by this Department as Farmers' Bulletin No. 314, "A Method of Breeding Early Cotton to Escape Boll Weevil Damage," by R. L. Bennett. A copy may be obtained by any planter by application to the Secretary of Agriculture.

Standard early varieties of cotton.—There are a number of standard varieties that have been found of value in weevil-infested regions the seed of which may be obtained from seed dealers. Among them are the Rowden, Triumph, Cleveland Big Boll, Cook's Improved, and King. All of these except the King have either medium-sized or large bolls. The King has a small boll, about 80 being required to make a pound, but is remarkably early and has given the best yields

in most of the experiments of the Bureau of Entomology.[a] Hawkins' Early Prolific and Simkins have given good results in recent experiments of the State crop pest commission of Louisiana. In all cases it will pay the planter to exercise care in obtaining seed. Wherever possible it should be obtained from the originator.

Heavy cotton seed.—The Department of Agriculture has called attention to the advantage of planting heavy cotton seed (see Farmers' Bulletin No. 285). This should be taken into consideration along with other means of obtaining an early and vigorous stand. Another recent suggestion of assistance in obtaining an early start in the spring is that the planting be facilitated by covering the seed with paste. This method will make it possible to use an ordinary corn planter in putting in cotton seed and facilitate the work of check-rowing. This matter is discussed fully in the Farmers' Bulletin just referred to.

Early planting.—Another step to be taken in obtaining an early crop, and fully as important as those that have been mentioned, is early planting itself. Naturally no set rule can be laid down as to the proper date for planting. There is much variation in the seasons, and it is sometimes impossible to place the fields in readiness as early as is desirable. Much of the effect of early planting is lost unless the seed bed is in good condition. Rather than plant abnormally early it would be better to improve the seed bed. It is not recommended that planting be made at dangerously early dates. Nevertheless, with proper preliminary attention to the fields it would be possible for farmers in most localities to plant from ten to twenty days earlier

[a] Some of the early maturing varieties of cotton happen to have small bolls, although the plant breeders hold that there is no necessity of an early maturing cotton having small bolls. In view of the fact, however, that some of the best known early maturing varieties at the present time have undersized bolls, occasional objections have been made to planting them. It is true that the picking of cotton from these varieties sometimes involves difficulties. In some cases it is known that pickers have refused to pick small-boll cottons while any other cotton was available despite the offer of additional payment on account of slow picking in the fields of the smaller bolled cotton. This is an actual, practical difficulty that must be taken into consideration. At the present time it is sufficient to call attention to the fact that the practical disadvantage of small bolls may not be as important as appears at first glance. For instance, if small-boll varieties yield 100 pounds of seed cotton per acre more than ordinary cotton, this gain would permit the farmer to pay 10 per cent more for picking, with profit. Thus:

750 pounds small-bolled cotton per acre picked at $1 per cwt., cotton at $3 per cwt., net profit	$15.00
650 pounds large-bolled cotton per acre picked at 90 cents per cwt., cotton sold at $3 per cwt., net profit	13.65
Difference in favor of small-boll cotton	1.35

than they are accustomed to at the present time. This, therefore, is the general recommendation that is made. It is much better to run the risk of replanting, provided the seed bed is in good condition, than to defer planting on account of the danger of cold weather. Of course it is possible to plant entirely too early, so that the plants become stunted during the early days of their growth. It is not intended that planting should be made early enough to have this effect upon the plants.

ADDITIONAL EXPEDIENTS IN HASTENING THE CROP.

It was pointed out in connection with the enemies of the boll weevil that under natural conditions a large percentage of the weevils is killed by heat and parasites. The wide spacing of the cotton plants augments the action of both these agencies working against the boll weevil. The effect of the sun heat has been studied in many cotton fields. The mortality becomes remarkably high during the hot days of summer. The farmer can take advantage of it, and even increase it. It is very conservative to state that the weevils will be able to multiply only half as fast in fields where there is plenty of distance between the plants as in fields where plants are close together and the branches cross from row to row. It should therefore be the rule of the planter in weevil regions to give considerably more distance to the plants in the drill and to the rows than he would give under ordinary conditions. On land that produces under normal conditions from 35 to 40 bushels of corn per acre the rows should be 5 feet apart. Even on poor soil it is very doubtful, except in dry regions of the West, whether the distance should ever be less than 4 feet.

Check-rowing.—Considerable attention has been attracted in some localities in Texas to the practice of check-rowing cotton to assist in the control of the weevil. Undoubtedly from this standpoint the practice is to be recommended highly. By following it each plant is given the maximum soil that it can use with consequent beneficial results upon its growth. The greatest possible amount of sunlight is allowed to fall upon the ground where the infested squares are found, to destroy many weevil larvæ outright and at the same time to facilitate the work of the numerous enemies of the weevil that occur in every cotton field. Check-rowing, moreover, saves much labor, thereby reducing the cost of production, and also makes easy the control of noxious weeds. The only important objection is that in some localities it may interfere with drainage.

Cultivation.—During the growing season of the crop the fields should be given very careful cultivations. Most of the benefits of early preparation, early planting, and fertilization may be lost in case the fields are not given the utmost attention subsequently. In

case of unavoidably delayed planting the best course to pursue is to cultivate the fields in the most thorough manner possible. Under most conditions the old plantation rule "once a week and one in a row" should be made to apply. This will not result in the direct destruction of many weevils, but it causes the plants to continue uninterruptedly in their growth. By all means such operations as deep cultivation, and cultivation close to the plants, which causes shedding, should be avoided. In many instances a fair crop already set and beyond danger from the weevil has been lost by running the plows so close that the side roots were cut and the plants have shed practically all the fruit. When this happens during the middle or latter part of the season the weevils will certainly prevent the putting on of any more fruit. The general practice of laying by, by scraping the middles with a wide sweep, leaves a hard surface which causes loss of moisture and shedding. Where the weevil occurs, every precaution must be taken to avoid shedding, as the insect will certainly prevent the maturity of the later fruit and, moreover, will be forced to attack bolls which would otherwise not be injured.

Effect of late cultivation.—A very conspicuous illustration of the disastrous effects of careless late cultivation came to the attention of the Bureau of Entomology during the present season (1908). It was learned that some planters in the Red River Valley below Shreveport, La., were making fair crops (in one case 600 bales on 900 acres), while others were making very small yields as, for instance, in one case 200 bales on 800 acres. Upon investigation it was found that all the planters in the neighborhood were compelled to put all their hands on levee work for five weeks to save their places. During that time the cotton remained uncultivated. After the subsidence of the flood the fields were plowed. Where this work was done carefully the good crops were being produced. In cases where the plows were run too deeply and too close to the plants excessive shedding had taken place and the weevils prevented the putting on of any more fruit. Careful investigation on several places where the essential conditions were identical left no doubt that the cause of the difference in yields was primarily the difference in summer cultivation.

Occasionally a farmer is found who has obtained better yields on fields where cultivation has been discontinued early. In fact, the writer has seen fields full of grass that were outyielding perfectly clean ones on the same plantation. Such situations have caused erroneous conclusions. As a matter of fact, the explanation is that the late, careless cultivations had done more harm than good. The importance of careful shallow summer cultivations can not be too strongly emphasized.

SPECIAL DEVICES FOR DESTROYING WEEVILS.

The impression is more or less general that the only important way in which weevils may be killed is by the removal of the infested plants and that all other steps in the system of control are merely to avoid damage by the weevils that have survived that destruction, and their offspring. In spite of this impression, however, it is urged that the destruction of myriads of weevils can be accomplished during the growing season. This is to be done by working in cooperation with the natural agencies that destroy the weevil.

In making examinations of many thousands of infested squares from different localities and different situations in cotton fields it was found that mortality was conspicuously greatest where the sunlight was least obstructed and the heat, consequently, the greatest. The mortality in infested squares in the middles was many times

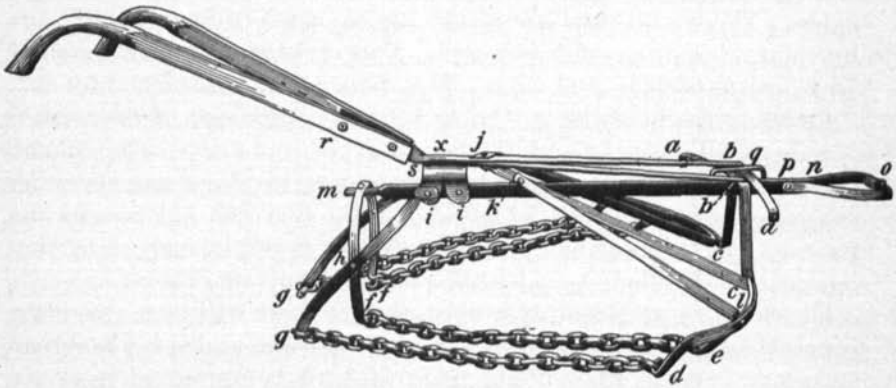

FIG. 6.—Chain cultivator, side view. (Original.)

as great as in the case of squares which remained under the shade of the branches. The temperature at the surface of the ground during warm days runs considerably higher than at a few feet above the surface. For instance, it was found that when the temperature was 100° F. in the regular Weather Bureau shelter about 4 feet above the ground the thermometer registered 140° F. on the surface. Likewise 90° F. in the shelter was accompanied by 120° F. on the ground and 85° F. in the shelter by 110° F. on the ground. It is not surprising, therefore, that the cotton squares that fall to the ground and are not shaded are very quickly baked, so that the weevils perish—if not from heat, then from the hardening of the food supply. In most cases they are simply roasted, their bodies assuming the appearance of larvæ that have been placed in a flame.

Chain cultivator.—When the foregoing facts came to light efforts were made to perfect a device that would bring the infested squares

out of the shade of the plants to the middles of the rows. After much experimental work one of the writer's former associates, Dr. W. E. Hinds, devised an implement that accomplishes the desired work in a satisfactory manner. This implement is known as the chain cultivator or chain drag.

The following specifications should enable any blacksmith to construct an effective chain cultivator. (See fig. 6.)

The draft bar (*n m*), made of $\frac{1}{2}$ by $\frac{5}{16}$ inch tire steel, about 52 inches long, is designed to be about 16 inches above the ground, and this is the height of the rear arch (*f h m*), which is of this size and form to allow old cotton roots, etc., to pass through freely without clogging at the rear.

The distance between the rear ends of the chains (*g g*, *f f*) is in each pair fixed at about 10 inches. The distance between a chain of one pair and that of the other at their front ends should be about 9 inches. The chains used are of the size known as "log chains," having short, close links of $\frac{3}{8}$-inch iron. This style of chain can be cut to the length needed in each case. The chain is easily attached by simply making the hooks at *d*, *e*, *f*, and *g* so that the end of the hook is as wide as will pass through the length of the link and narrow enough at the middle of the bend to allow the link to turn and bag the other way. So long as the chains are kept tight they can not become unhooked. The hooks should also be turned, or faced, in such a way that they will not be likely to catch the passing plants or rubbish.

The clevis (*o p*) is simply hinged, so that there will be no tendency to pull the front of the machine off of the ground, and it is also broad enough in front to allow of the point of draft being moved from one side to the other, so that the front of the machine may be thrown closer to one row if desired.

The front guard on each side (*a b c d*) is made of one piece of spring steel, $\frac{7}{8}$ by $\frac{3}{16}$ inch. This size seems sufficiently strong and best adapted to carry the tension of the chains (*d g*) while still yielding to the pressure against the bases of the plants as they may strike the outer, sloping ends near *d*. The inner ends of these guards (*a b*) are horizontal, about 18 inches each in length, and serve to carry the front guard above the draft bar (*n m*) and, passing through the keeper (*q*), guide in the adjustment for width. The machine can not be extended beyond the bent ends at *a* or closed beyond the angles at *b*. The vertical section between *b* and *c* is about 12 inches long, so that the remainder of the front guard from *c* to near *d* will be about 4 inches above the ground. This prevents the pushing of dirt and squares toward the plants and allows the chains to catch them where they lie. The hooks at *d* and *e* are therefore bent downward and somewhat backward through about 5 or 6 inches. Care must be taken

especially in forming the outer ends between *c* and *d* to secure best results. The downward bend for the hook at *a* should not be abrupt, as a gradual slope helps to prevent catching on any obstacles. The hooks at *f* and *g* are formed so as to hold the chains firmly and yet not interfere with the passage of rubbish. The method of carrying the rear ends of the outer chains is shown at *i h g*. The piece *k l* is nearly parallel with the chains and may be used for their proper adjustment as to tension by several holes near the end where it is bolted at *k*. The chains are between 30 and 36 inches long. The stand *s* upon which the handles are pivoted by a ½-inch bolt is made of a piece of boiler plate bent and cut so as to have a horizontal top surface about 4 inches square and standing about 2½ inches above the draft bar, to which it is securely bolted. The handles are bolted, as at r, to the heavy pieces of iron (about 2 by ½ inch tire steel) which are bent to receive them just behind the pivotal point at *x*, at such an angle as to bring the handles to the proper height and position. In front of *x* these pieces bearing the handles need not be so heavy and may therefore be tapered and welded to smaller steel running forward to *b*, where it is bolted to the front guard. The operation of this arrangement is similar to that of a huge pair of shears—when the handles are pushed apart the front of the machine is spread wider, and vice versa. The braces *j c e* serve to support, strengthen, and carry the front guard. They are riveted to the adjusting irons at *j*, one above and one below the "shear" pieces, to prevent their interference with the closing of the machine. At *c* this iron is bent to conform to the front guard, to which it is riveted between *c* and *l*, at which point it is bent downward and forms the hook *e*. Ordinary tire steel about 1 by ¼ inch may be used for all parts like the clevis (*o p*), rear arches (*f h m* and *i h g*), and braces (*k l* and *j c e*). The front guard (*a b c d*) should be of spring steel, as specified. The rivet heads on the front guard should be round and fit smoothly. In nearly all other places the irons are fastened together by ¼-inch square-headed bolts, with washers as needed.

In operation the implement is drawn by a single animal. The chains at *d* and *e* pass under the branches of plants and close to the stems. The forward motion of the machine causes these squares to be drawn inward by the chains, which must be kept taut, and leaves them in a narrow pathway where the chains approach within a short distance of each other at the opposite end of the machine. (See figs. 7, 8.) The two chains are provided so that squares that may pass over the first are taken up by the second on either side. In actual practice it has been found that more than 90 per cent of squares may be brought to the middle of the rows. This means that the natural mortality among the weevils due to the effects of sunshine can be at least doubled.

Although the chain cultivator was designed primarily for bringing the squares to the middles, it was found in field practice to have a most important cultural effect. The chains (so-called "log chains") are heavy enough to establish a perfect dust mulch (see figs. 7 and 8) and to destroy small weeds that may be starting. In fact, it is believed that this cultural effect would more than justify the use of the machine, regardless of the weevil. With the effect against the insect and the important cultural effect it is believed that this implement or

FIG. 7.—Work on the chain cultivator: Cotton row before use of cultivator, showing fallen squares, crack, and rough condition of ground. (Original.)

one similar to it should be used by every farmer in the weevil territory.

In order that the use of this machine could be obtained by all farmers at the smallest possible cost, a patent has been taken out in the name of the Department of Agriculture and for the benefit of the people of the United States. Under this patent it is impossible for anyone to manufacture the machine exclusively and to charge unnecessarily high prices.

Attachments for ordinary cultivators.—Some of the effects of the chain cultivator may be obtained by attaching chains to ordinary cultivators by the use of special attachments. In this way some of the effect of the chain drag would be added to the work of the cultivator. Wherever for any reason it is impossible to obtain chain drags, it is suggested that the principle be incorporated in some simple attachments to cultivators.

FIG. 8.—Work of the chain cultivator: Same row shown in fig. 7, after cultivator has passed; majority of squares brought to middle, crack filled, and dust mulch established. (Original.)

The use on ordinary cultivators of an arm or projection that will brush or agitate the plants in passing will assist to a certain extent in destroying the weevil. The squares will be knocked to the ground earlier than they would fall, and this would naturally increase the effect of heat. At the same time a very few adult weevils will be knocked to the ground, but this has been found to be unimportant. In repeated experiments in jarring and beating cotton plants on which known numbers of weevils were found it was ascertained that

very few, if any, left the plants by reason of any agitation that would not break the branches or bark the stems. Occasionally, however, a weevil passing over a leaf is jarred to the ground. Often entirely too much stress is placed upon the importance of jarring the adult weevils to the ground. When specimens are collected by hand and thrown on the surface of the ground, especially if it be finely pulverized, the great majority will be killed almost instantly by the heat. This has caused the mistake on the part of careless observers of supposing that many weevils could be killed by jarring them to the ground. The difficulty, as pointed out, is that it is totally out of the question to jar more than one weevil out of many hundreds to the ground by any process that would not injure the plants severely. Nevertheless, the effect of a cross-arm of wood or iron whipping through the tops of the plants is recommended for the reason that the squares are thrown to the ground, where the heat has its earliest possible effect upon them.

HAND PICKING OF WEEVILS.

Gathering the weevils by hand is an operation of limited applicability. Where the fields of cotton are small and there is an abundance of labor it is sometimes practicable to pick the early emerging weevils from the plants and later to pick up the early fallen squares. Everything depends, however, on the conditions being favorable. On large places it will undoubtedly not often be found practicable to carry on this process. In an experiment performed by the Bureau of Entomology on a plantation worked by convict labor, giving the optimum conditions for the experiment, no results whatever followed thorough pickings twice each week for two months in the spring, beginning with the appearance of the first weevils. In another instance, at Gurley, Tex., more than 40,000 weevils were picked on an area of 8 acres by means of paid labor, beginning in April and continuing until July. On the 8 acres where this work was done a crop of about 50 pounds per acre in excess of that on other areas was obtained. This was not sufficient, however, to pay for more than a very small fraction of the work done. From these and other experiments the Bureau of Entomology recommends in a guarded manner the picking by hand of weevils and squares. Undoubtedly good may be accomplished under certain conditions, but planters should be careful not to depend too much upon it and not to make too great an outlay for it.

Disposition of adult weevils and infested squares.—When adult weevils are picked by hand they should be killed by means of oil or fire, or buried deeply in the ground. When infested squares are picked, however, an entirely different procedure should be followed. Many of the

weevil larvæ in the infested squares will be found to harbor parasites. It is entirely practical, as has been pointed out by Mr. Wilmon Newell, of the Louisiana crop pest commission, to let these parasites develop and continue their work against the weevils in the fields. This is done simply by placing the infested squares in wire cages. The parasites, on account of their small size, will escape, while the weevils soon die from a lack of food. The meshes of the wire of the cage should be at least 16 to the inch. However, some weevils will escape through this mesh, and about 5 per cent through a 14-mesh screen. Even if the finer wire can not be obtained, it is advisable to use what can be had. A calculation will show that there is a direct advantage even if a few of the weevils escape, if all of the parasites do. By burning or destroying the squares in any other way the farmer is simply working against and counteracting an agency in the control of the weevil that is much more important than any amount of hand picking he is likely to be able to do.

TOPPING OF PLANTS.

The practice of topping plants is sometimes recommended for fields infested by the boll weevil. The results of work by different experiment stations have shown that topping has exceedingly uncertain general results. As often as otherwise it decreased instead of increased the crop. In any case the topping of plants can probably do no harm in fields that are being damaged by the weevil. It is probable that the general results will be beneficial in causing the more rapid growth of the crop on the lower and middle branches. It has never been possible to demonstrate this in an exact way. Nevertheless, for the general effects stated the topping of plants is included among the recommendations that should be followed, although as one of minor importance.

COTTON LEAF-WORM AND BOLL WEEVIL.

The relation between the formerly dreaded leaf-worm or so-called "army-worm" and the boll weevil deserves special attention. A quarter of a century ago the efforts of entomologists and planters were directed toward some means of destroying the leaf-worm. The use of Paris green was found to be effective. Various changes in the general system of cropping cotton also caused the injuries of the leaf-worm to become less conspicuous year after year. Even up to the time of the spread of the weevil into Texas, however, poisoning was a more or less regular operation on all cotton farms. The insects never did any considerable damage before the middle or latter part of the season. The object in destroying the leaf-worm was that it prevented the maturity of a fall crop. For this reason the

saving of the top crop and in exceptional seasons a part of the middle crop was all that was desired. The work of the boll weevil has changed all this. After the careful studies that have been given the problem it is evident that no top crop of cotton can be expected in infested regions. This, of course, reduces the leaf-worm to an insect of no importance where the boll weevil exists.

The change has actually been even greater than this, for the work of the leaf-worm has a disastrous effect upon the boll weevil. As has been pointed out in the discussion of fall destruction, the late developing weevils are the ones that pass through the winter. Consequently, if the leaf-worms defoliate the plants and stop the formation of squares, a certain degree of fall destruction is accomplished. It can never be as satisfactory as the poorest artificial fall destruction, because the plants continue to leaf out after the defoliation by the worms, thus giving the weevils a supply of succulent food. It is not recommended that the work of the leaf-worm be depended on in place of fall destruction. Nevertheless, allowing the leaf-worms to proceed with their work, or even encouraging them, will assist as a general procedure against the boll weevil at least when, for any reasons, the more important steps are not taken. In some cases where the injury by the leaf-worms begins unusually early, it may still be advisable to check it by poisoning in the well-known manner, but save in such exceptional circumstances it will now be better to allow the leaf-worm to work unrestrictedly.

It has been suggested by Mr. Wilmon Newell that in special cases where there are difficulties in the following of the fall destruction of the plants, it may be advisable to take means to encourage the leaf worm. This could be done by breeding larvæ and pupæ to be scattered in the fields and by carrying the pupæ from localities, as the hills, where they appear first, to the valley fields, which are normally not reached until some time later.

DESTROYING THE WEEVIL IN COTTON SEED.

It has been abundantly shown that cotton seed is of importance as a medium through which the weevil may be carried. Many individuals that happen to be carried to the gin on the cotton pass uninjured through the gins to the seed houses. Consequently every seed house connected with a gin in the infested territory harbors more or less weevils, depending upon the amount of cleaning the staple is given. Of course such seed is exceedingly dangerous when taken into uninfested regions. Undoubtedly the present absolute embargoes against cotton seed from the infested region are wise. In general, they should be strictly construed. In some special cases, however, when, for instance, it is desired to obtain special improved seed,

proper precaution can be taken to destroy all weevils by means of fumigation with carbon bisulphid. The method was described by the writer in Farmers' Bulletin 209, from which the following is quoted:

The following plan for this work is proposed: A tight matched-board box should be provided having sides 4 feet high, open on top, and of other dimen-

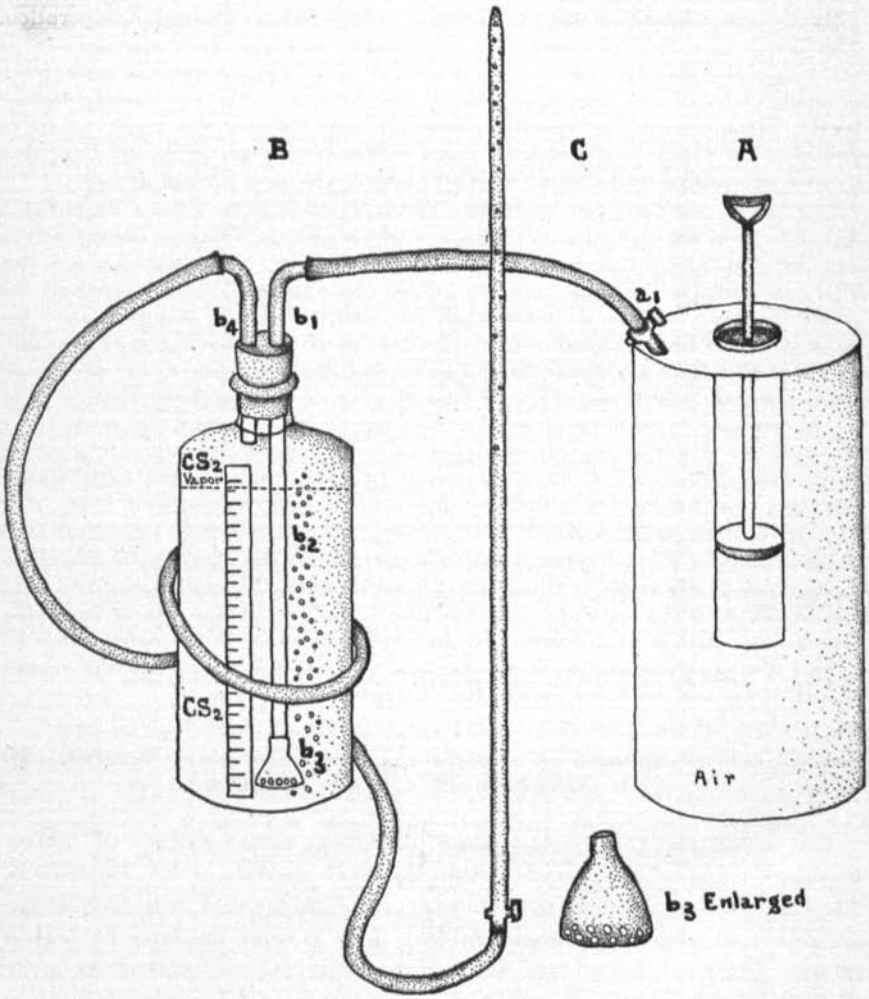

FIG. 9.—Apparatus for fumigating cotton seed in the sack. (Author's illustration.)

sions to accommodate 12 or more 100-pound sacks of cotton seed placed upright upon the bottom. Another tier of sacks could be added if desired. Into each one of these sacks about 1 ounce of carbon bisulphid should be forced by an apparatus for volatilizing the liquid and mixing the vapor with air. The accompanying illustration (fig. 9) will give an idea of this apparatus. It should consist of three essential parts, as shown in the illustration. *A* is an air pump having sufficient storage capacity to enable it to maintain a steady discharge of

air for several minutes without continuous pumping. The stopcock at a_1 regulates or prevents the escape of air, as may be desired. *B* is an ordinary 2-quart bottle fitted at b_1 with a tight stopper of good length, having two openings, through which the inlet and outlet pipes pass. These pipes may be of glass or metal and should be as large as can be used. The inlet pipe, b_2, reaches nearly to the bottom of the bottle and is provided at the lower end with a perforated metal cap as large as will pass through the neck of the bottle. This allows the escape of the air in small bubbles and insures rapid evaporation. The outlet pipe, b_4, reaches only through the stopper. Upon the outside of the bottle is pasted a paper marked with 1-ounce graduations. *C* is a piece of ordinary ⅜-inch iron gas pipe about 3½ feet long, but this may be any desired length. It is closed and roundly pointed at the tip, and for about 15 to 18 inches of its length provided with small perforations pointing in all directions to give free escape to the vapor into all parts of the sack of seed at once.

The connections may be of rubber tubing, but as little rubber as possible should be used for this apparatus, as it is affected by the vapor of the bisulphid, and the couplings will have to be frequently replaced. This, however, will not be a considerable item of expense. With the apparatus just described one operator would be able to accomplish the entire work of disinfection. The amount of carbon bisulphid recommended is about 1 ounce for each 3-bushel sack. It is safe to say that this can be secured for less than 1 cent per ounce when purchased in 25 or 50 pound lots, making the cost of bisulphid not over 1 cent per sack. As it requires but from two to three minutes to vaporize 1 ounce of the liquid in the manner described, the expense for labor in application would not amount to one-half a cent per sack. Fumigation with carbon bisulphid can therefore be effectively made at the slight expense of from 1 to 1½ cents per 100-pound sack.

Application of the bisulphid in this manner reduces the elements of danger to a minimum, as the vapor is almost wholly confined and the slight quantity escaping, mixed with the open air, would not be in either inflammable or explosive proportions. It has been determined that the slight trace of bisulphid vapor in the air would not injure the operator in the slightest degree. The sacks should be left in the box for forty hours after the gas is injected.

RELATION OF MEANS OF CONTROLLING THE BOLL WEEVIL TO THE CONTROL OF OTHER INSECTS.

The cotton bollworm.—The most important insect enemy of cotton in the United States, aside from the boll weevil, is the bollworm. This pest has existed in this country for many years and frequently reduces the crop very considerably. The annual damage to cotton in the United States has been conservatively estimated at over $8,000,000. In addition to the injury to cotton this insect is a very important enemy of corn, tomato, okra, cowpeas, and some other crops. Careful studies of the bollworm were conducted by Mr. A. L. Quaintance, of the Bureau of Entomology, in connection with large-scale field experiments in many localities. The conclusions drawn from this practical work were that the essential steps to be resorted to in the control of the boll weevil are exactly the ones that should

be followed in the warfare against the bollworm. The following is the statement by Mr. Quaintance on this subject:

The steps in the production of early cotton, outlined above, include the principal recommendations for the growing of cotton in the presence of boll weevils. It is therefore seen that injury from the cotton bollworm and the cotton boll weevil may be best avoided by the adoption of one and the same course of improved farm practice. The spread of the latter species will render imperative the adoption of these methods in profitable cotton culture, and along with this change the ravages of the bollworm during normal seasons should become less and less.

The cotton aphis.—Of the numerous minor enemies of the cotton plant in the United States there is one, the cotton aphis, or plant-louse, that may occasionally cause unusual damage by reason of early planting. This will only happen to any appreciable extent during wet seasons. Under such conditions the aphis may sometimes make it necessary to replant.[a] Nevertheless, this is not an important difficulty. It is not of sufficient moment to be considered at all, in view of the enormous benefit in avoiding damage by the boll weevil by means of early planting. If the other steps in the control of the boll weevil be taken and the fields made clean during the winter and the rubbish in the fence corners and along the turnrows destroyed, it is not likely that the aphis will do any considerable damage, even during the coolest and wettest springs.

The injury inflicted by several other insects, such as the cotton square borer, webworm, and cutworms often makes the crop somewhat later, and consequently likely to be injured by the weevil.

GENERAL CONTROL THROUGH QUARANTINES.

There is no doubt whatever that the weevil can not be prevented from extending its range to the extremes of the cotton belt in this country. However, the damage is so great and the disturbance of economic conditions so extensive that all reasonable precautions should be taken to prevent the early accidental importation of the weevil to uninfested regions. Practically all of the States in the cotton belt have enactments designed to this end. Undoubtedly they should be enforced to the fullest extent.

At one time considerable inconvenience was caused the shipping interests by the lack of uniformity of quarantines in different States and the inclusion of articles in which there is very little danger. At the present time these difficulties have largely been removed. All that it is advisable to include in the absolute quarantines are cot-

[a] On the contrary, cases have been noticed where early breaking and thorough working caused a lessening in the number of aphides, due to the destruction of the ant that protects them. Mr. Wilmon Newell calls our attention to an instance of this kind in Louisiana in 1908.

ton seed, seed cotton, cotton-seed hulls, and baled cotton. These commodities are likely to carry the weevil with them. In fact, it has been amply demonstrated that the insects are frequently carried in this way. Other articles, and even empty cars, may occasionally transport weevils, but the degree of danger is so much less than in the cases of the articles specified above that they do not need to be taken into consideration.

It is entirely feasible to eradicate small isolated colonies of the boll weevil. An important office of the State authorities, concerned in State quarantines should therefore be to investigate reported outbreaks of the weevil and be prepared to take the necessary steps toward eradication at the earliest moment. The Bureau of Entomology will assist the state authorities in any cases of this kind.

ATTEMPTS TO POISON THE BOLL WEEVIL.

From the very beginning of the fight against the boll weevil attempts have been made to poison it. In 1894 and 1895, in the region originally infested in Texas, agents of the Bureau of Entomology conducted careful experiments with poison. Since that time various advocates of poisons have appeared. The idea appeals so strongly to farmers that these advocates have sometimes enlisted considerable followings. This has made it necessary for the Bureau of Entomology to carry on a large number of special investigations relating to poisons. In order to understand the difficulty of poisoning it must be remembered that during the growing season the boll weevil feeds only by inserting its beak deeply into the squares or bolls. It is therefore entirely out of the question to place the poison in a position where the insect will feed upon it.

Early in the season, however, before any squares are formed, the hibernated weevils that may have emerged feed upon the opening leaves on the so-called bud of the young cotton plant. At this time it is possible to destroy a considerable percentage by the application of poison. In all experiments performed in the field by the Bureau of Entomology very heavy applications throughout the season from chopping to picking have failed to show any advantage in the use of poison. Even light applications have been found to have insidious injurious effects upon the plants. The reason for the ineffectiveness of poisons is that the great majority of the weevils do not emerge from hibernating quarters until after the squares have begun to be formed. The destruction of some of the early emerging individuals does not prevent the remainder from causing complete infestation of the fields at the usual time.

Arsenate of lead.—Recently Mr. Wilmon Newell, of the State crop pest commission of Louisiana, has published a preliminary report

regarding experiments with powdered arsenate of lead as a poison for the boll weevil. This substance has the advantage of being absolutely harmless to the plants, whereas Paris green applied to the tender terminal growth frequently causes the plants to become stunted, to remain so throughout their lives. Although the powdered arsenate of lead has this advantage, the question still remains as to whether enough weevils can be poisoned to result in any special benefit to the crop. The following is Mr. Newell's statement on this subject:

> As it is, the profit to be derived from applying the powdered arsenate of lead when the cotton is in the budding stage can only be determined by actual tests in the field, in which the production of poisoned and nonpoisoned cotton (both under conditions otherwise exactly alike) is carefully determined.

It will be noted from Mr. Newell's statement that no field experiments have been carried on to determine whether any direct benefit can be obtained from the use of powdered arsenate of lead. The Bureau of Entomology therefore urges that until further notice no farmers go to the expense of attempting to poison the boll weevil in any way.

Many attempts have been made to cause poisoned substances to be attractive to the weevil by introducing sweets and other ingredients. All these have failed completely. Some known sweets, such as honey, have a slight attraction for the weevil, but not enough to assist in practical control even regardless of their expense.

Contact poisons.—Poisons designed to kill the weevil by suffocating rather than by being taken into the digestive organs, have been proposed. They can not, of course, be effective against the immature weevils within the cotton fruit. The difficulties in reaching the adults are in their manner of work. Normally these insects are found inside the bracts of the squares, where they can not be reached by sprays. In fact, nature designed the bracts to prevent the heaviest rains from reaching the square within. An additional difficulty is in the expense of applying sprays, not only on account of labor, but on account of the special machinery that is necessary. Although there is some very remote possibility that dry poisons may be found of assistance in controlling the weevil, on account of the facts mentioned it is not at all probable that liquid sprays can ever be used.

Effect of confinement.—There is one peculiarity of the weevil that has led to many unwarranted claims as to the efficacy of remedies. The insect will die within a very short time when confined in a bottle or jar or even in a cage. Even when cages are placed over growing plants it is found that numbers of the insects die and fall to the ground, though no poison has been applied. In many instances experimenters have applied their preparations under such conditions

and have found dead weevils later. They have made no allowance for the weevils that would have died under these conditions without any treatment whatever. In such experimental work special pains should always be taken to provide one or more careful checks upon the weevils that have been subjected to treatment.

FALSE REMEDIES.

The extreme seriousness of the boll-weevil problem has called forth many hundreds of suggestions in control. These have covered such methods as changes in manner of planting, attracting the insects to food plants or lights, soaking the seeds to make the plants distasteful, sprays, machines, smokes, and the planting of various plants supposed to be repellent. In many cases these suggestions have been made without due understanding of the habits of the weevil. In other cases practical features, such as the cost of application, have not been considered. The following paragraphs deal with some of the principal fallacious methods that have been proposed.

Late planting.—Foremost among the futile means of control is late planting. At various times different persons have suggested that late planting, especially if following early fall destruction, would so lengthen the hibernating period that no weevils would be permitted to survive. Very numerous experiments in the field and in cages have proved that the weevils in considerable numbers are able to survive from any reasonable time of early destruction in the fall to beyond the date in the spring when any return whatever could be expected from planting cotton, even if the weevils were entirely eliminated. In a field experiment performed in Kerr County, Tex., the plants were removed very thoroughly early in November. No stumpage or volunteer plants were allowed to grow during the winter. There was no other cotton planted within 9 miles. On the experimental field planting was deferred until June 10. In spite of this fact weevils appeared as soon as the plants were up and multiplied so rapidly that the production was not sufficient to warrant picking. A similar experiment was carried out under different conditions by the State crop pest commission of Louisiana and the results published in Bulletin 92 of the Louisiana Experiment Station. The results obtained in Louisiana agree in every way with those obtained by the Bureau of Entomology in Texas.

The reasons for the failure of late planting are evident from a study of the habits of the insect. In many cage experiments it has been found that the last emerging weevils in the spring appear well into the month of June. In fact, emergence has taken place as late as the 27th and 28th of June. Without any food whatever the emerging weevils are able to survive for some time. The maximum

known survival of any hibernated weevil without any food whatever after emergence was 90 days and a considerable number lived from between 6 to 12 weeks after emergence. This ability to survive without food, together with the late emergence, render it entirely out of the question to exterminate the boll weevil by late planting. Moreover, there are always to be found along roads, turn-rows, in cotton fields, and elsewhere, a considerable number of volunteer plants which come from seed scattered accidentally or blown from the bolls during the fall. These plants, starting early in the spring in such numbers as to be beyond control, would furnish a means for the weevils to subsist to the time of planting, regardless of how late it might be. In 1906, for instance, at Dallas, Tex., it was found that volunteer plants appeared in the spring at the rate of about 1,000 per acre. An investigation showed that the number of such plants increases to the westward as the climate becomes drier. Nevertheless, numbers of plants were found near Memphis, Tenn., and Vicksburg, Miss., in a region of more than 50 inches of annual precipitation.

Trap-rows.—The idea of attracting weevils to a few early plants or trap-rows seemed hopeful at one time. Practical work in the field, however, has shown that nothing whatever can be expected from this means. The difficulty is that the early plants exert very little attraction. Moreover, before the majority of the weevils have emerged from hibernation the planted cotton is always large enough to furnish them plenty of food. In practice it has been found impossible to defer planting long enough to concentrate any appreciable number of weevils on the trap plants. Trapping weevils to hibernating quarters is an equally mistaken idea. They can not be induced to resort to any particular places. It is likewise impossible to attempt to make the cotton fields more favorable for hibernation than places outside of the field.

There is one way in which trapping may occasionally be resorted to with good effect. When the plants are destroyed in the fall and the weather is so warm that the majority of weevils have not entered hibernation, many of them will be found upon the plants that are left. Under these conditions the farmer can leave a few trap-rows to good advantage. They should be uprooted and burned within ten days of the time the other plants are destroyed, to kill the weevils that may be found upon them. Hand picking at frequent intervals before destruction may be practicable where labor is inexpensive.

Attraction to lights.—Many insects more or less resembling the boll weevil are attracted to lights. This has caused many persons to attempt to destroy the cotton pest by taking advantage of the supposed habit. It has been found, however, that the boll weevil is not

attracted to lights to any extent whatever. In one experiment a number of strong lanterns were placed in cotton fields in Victoria County, Tex. In all, 24,492 specimens of insects were captured, representing about 328 species. Of these, 13,113 specimens belong to injurious species, 8,262 to beneficial species, and 3,111 were of a neutral character. Not a single boll weevil was found among all these specimens, notwithstanding the fact that the lights were placed in the midst of fields where there were millions of these insects.

Chemical treatment of seed.—It is scarcely necessary to call attention to the fallacy of attempting to destroy the boll weevil by soaking the seed in chemicals in a hope of making the plants that are to grow from them distasteful or poisonous to the insect. Any money expended by the farmer in following this absurd practice is entirely wasted.

Other proposed remedies.—Many remedies for the destruction of the weevil, consisting of sprays, poisons, and fumigants or "smokes," have been proposed. Hundreds of these proposed remedies have been carefully investigated. The claims of their advocates in practically all cases are based upon faulty observations or careless experiments. The strong tendency of the weevil to die in confinement, which has been referred to, has caused many honest persons to suppose that the substances they are applying have killed it. Moreover, an insuperable difficulty that these special preparations have encountered is the impracticability of the application in the field. Hundreds of known substances will kill the weevil when brought in contact with it. The difficulty is to apply them in an economical way in the field. A striking instance of the unwarranted claims of some discoverers of "remedies" for the weevil was the case of a man who demonstrated the efficacy of his preparation by placing a feather in the bottle containing it and applying this to a weevil in his hand. Of course the death of the weevil was very far from a demonstration of the practical working of the supposed remedy. On account of the many difficulties in reaching the weevil and the necessity of obtaining special machinery for applications of poisons or sprays in the field, it is now considered, after much careful experimentation, that there is only the remotest hope of any such substances being of any practical avail whatever in the fight against the boll weevil. The claims made at different times of the repellent power of tobacco, castor-bean plants, and pepper plants against the boll weevil have no foundation whatever. In fact, none of these plants has the least effect in keeping weevils away from cotton.

Mechanical devices.—Many machines have been constructed to collect the weevils from the plants, or the bolls and squares from the ground. These have consisted of suction and jarring devices. Many

of them will destroy a certain number of weevils, but the habits of the insect are such that none has been found to yield results that pay even a small portion of the cost of operation. It is emphasized in this connection that there are plenty of proper ways in which all available mechanical ingenuity may be utilized in the fight against the weevil. There is great need for effective machines for assisting in the destruction of the weevils in the fall, and also for assistance in the cultivation of the crop. The present implements for cultivation, while effective in their way, could be improved in many respects, especially for the purpose of hastening the maturity of the crop. For instance, cultivators like the chain-cultivator mentioned in this bulletin, to establish a dust mulch rather than to plow the ground, are much needed. There are some cultivator attachments, such as the spring-tooth attachment, which are exceedingly useful tools in maintaining a surface dust mulch, but these are not as yet in general use.

SUMMARY.

The following is an outline of the practical methods of controlling the boll weevil described in detail in the preceding pages. These methods are based upon extensive studies and much field experimentation. They represent practically all that is known about combating the most important enemy of the cotton plant. They form a system consisting of several parts. The planter can insure success in proportion to the extent to which he combines the different essential parts.

(1) Destroy the vast majority of weevils in the fall by uprooting and burning the plants. This is the all-important step. It results in the death of millions of weevils. It insures a crop for the following season.

(2) Destroy also many weevils that have survived the preceding operation and are found in the cotton fields and along the hedgerows, fences, and buildings. This is done by clearing the places referred to thoroughly. (See pp. 22–23.)

(3) As far as possible, locate the fields in situations where damage will be avoided. This can not be done in all cases but can frequently be done to good advantage.

(4) Prepare the land early and thoroughly in order to obtain an early crop. This means fall plowing and winter working of the land.

(5) Provide wide rows, and plenty of space between the rows and the plants in the drill, for the assistance of the natural enemies of the weevil, which do more against the pest than the farmer can do himself by any known means. Check-rowing, wherever practicable, is an excellent practice.

(6) Insure an early crop by early planting of early-maturing varieties, and by fertilizing where necessary.

(7) Continue the procuring of an early crop by early chopping to a stand and early and frequent cultivation. Do not lose the fruit the plants have set by cultivation too deep or too close to the rows.

(8) Where the labor is sufficient, pick the first-appearing weevils and the first-infested squares. Do not destroy the squares but place them in screened cages. By this means the escape of the weevils will be prevented, while the parasites will be able to escape to continue their assistance on the side of the farmer. (See pp. 34–35.)

(9) Use a crossbar of iron or wood, or some similar device, to cause the infested squares to fall early to the ground, so that they will be exposed to the important effects of heat and parasites.

(10) Do not poison for the leaf-worm unless its work begins at an abnormally early date in the summer.

(11) Do not go to the expense of buying special preparations for destroying the weevil. Disappointment and loss is certain to follow. In case of doubt communicate at once with the Bureau of Entomology or with the entomologist of the State experiment station.

SPECIAL TREATMENT OF SMALL AREAS.

In some cases, where, for instance, a farmer has a small area of cotton growing for seed selection, it is practicable to resort to special means of control that would be impossible in general field practice. For the benefit of the many farmers in the infested area who are beginning to improve their cotton by selection, the following suggestions are made: The plat or plats should be far from timber, hedgerows, seed storage houses, and other protection for hibernating weevils. On the appearance of the earliest weevils the plats should be carefully picked over by hand. This should be continued until well after the squares begin to fall. If the falling of the squares continues it will be found practicable to rake them by hand to the middles or entirely outside of the plats to a bare place, where the sun will soon destroy the larvæ within. Of course all other general suggestions that are applicable in the field should be added to these special ones.